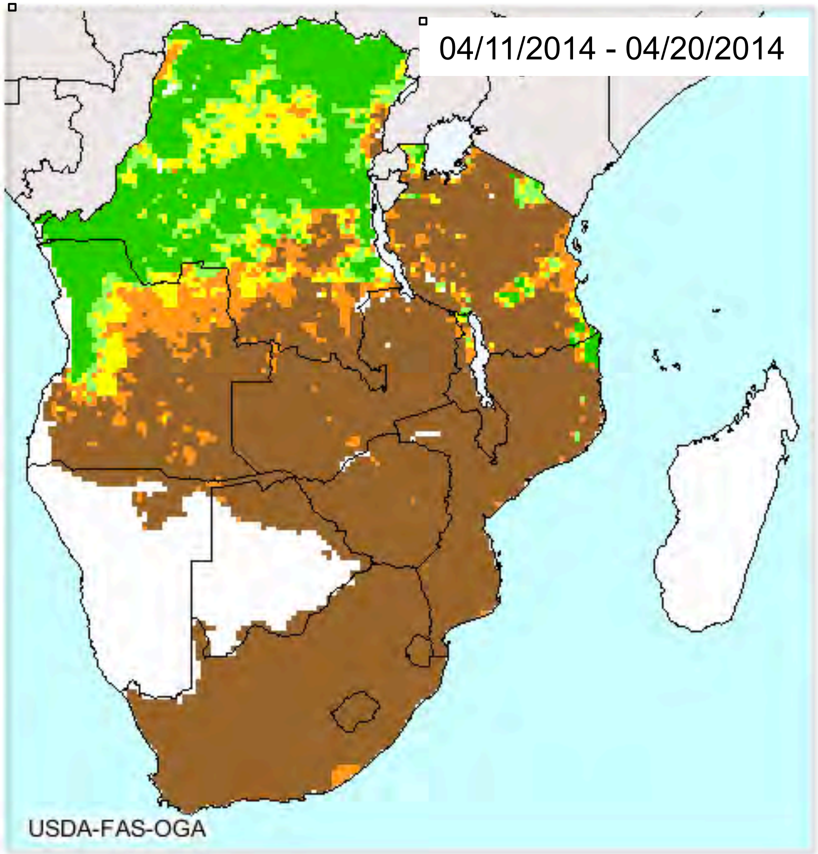
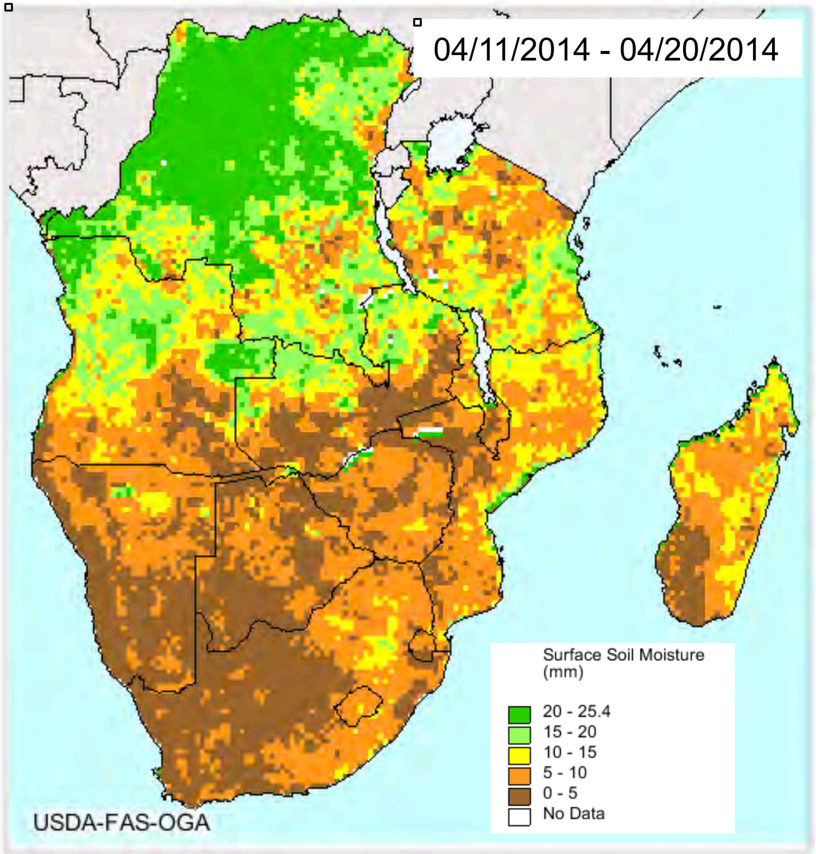
# USDA Foreign Agricultural Service Operationally Applying NASA Soil Moisture Product For Improved Agricultural Forecasting

John D. Bolten, Code 617, NASA GSFC

## Model




## Model + satellite observations




http://www.pecad.fas.usda.gov/cropexplorer/

**Satellite-based soil moisture observations are improving USDA's ability to globally monitor agricultural drought and predict its short-term impact on vegetation health and agricultural yield.**

Name: John D. Bolten, NASA/GSFC, Code 617
E-mail: john.bolten@nasa.gov
Phone: 301-614-6529

**References:**

E. Han, W.T. Crow, T. Holmes, J.D. Bolten (2014), Benchmarking a soil moisture data assimilation system for agricultural drought monitoring. Journal of Hydrometeorology, 1117–1134. doi: http://dx.doi.org/10.1175/JHM-D-13-0125.1.

Bolten, J.D., and W.T. Crow (2012), Improved prediction of quasi-global vegetation conditions using remotely-sensed surface soil moisture, Geophysical Research Letters, 39, L19406, doi:10.1029/2012GL053470.

W.T. Crow,  S.V. Kumar, S. V., J.D. Bolten (2012), On the utility of land surface models for agricultural drought monitoring, Hydrological Earth System Science, 16, 3451-3460, doi:10.5194/hess-16-3451-2012.

**Data Sources:**

Surface soil moisture retrievals are obtained from gridded 0.25° Soil Moisture Ocean Salinity (SMOS) products provided by the NOAA Soil Moisture Operational Product System (SMOPS). Daily precipitation and temperature data are provided by the Air Force Weather Agency (AFWA).

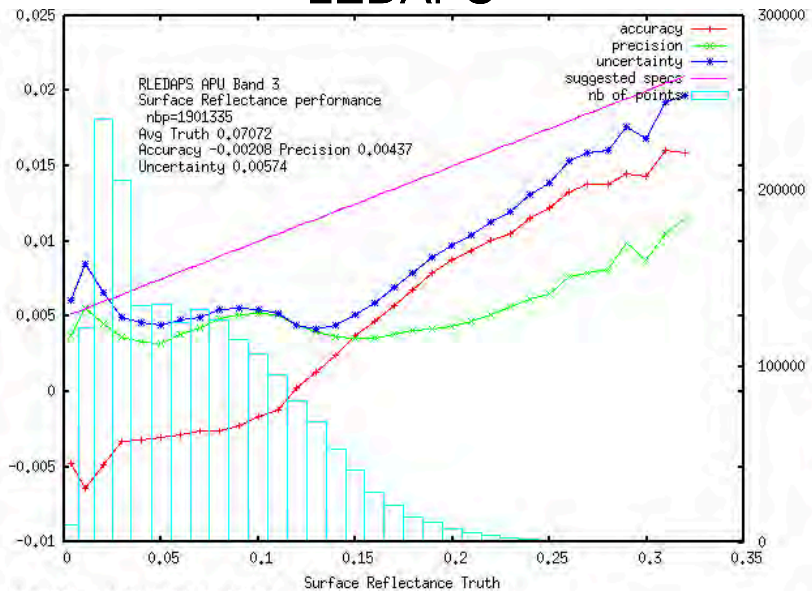
**Technical Description of Figures:** This image shows a screen capture of two 10 day average surface soil moisture products posted on the USDA Foreign Agricultural Service (FAS) Crop Explorer website for mid-April, 2014 (04/11/2014 - 04/20/2014) for southern Africa. Surface soil moisture is the water stored in the top layer of soil (defined here as that which has a water holding capacity of 25.4 mm).  Given a porosity of 45%, the top layer would be 56 mm deep.The image on the left is the Air Force Weather Agency (AFWA) - based soil moisture product that is heavily dependant on AFWA precipitation forcing and has a relatively high uncertainty in the region due to the poor rain gauge density in southern Africa. The poor rain gauge density results in data gaps and limited spatial variability when applied to the USDA FAS soil moisture model. The figure on the right has improved spatial heterogeneity and data coverage from the integration of near-real time soil moisture observations from the Soil Moisture Ocean Salinity (SMOS) mission, which were assimilated into the USDA FAS forecasting system soil moisture model using a 1-D Ensemble Kalman Filter (EnKF). The satellite-based product began to be operationally integrated into the USDA FAS system in Spring of 2014.

**Scientific significance, societal relevance, and relationships to future missions:** Resulting from this NASA Applied Sciences Program-supported project, the USDA FAS is implementing enhanced surface and root-zone soil moisture products in order to yield improvements in their crop forecasting system. The application of satellite-based soil moisture estimates (previously from the EOS Advanced Microwave Scanning Radiometer (AMSR-E) and now from SMOS) into the FAS soil moisture model provides significant improvements to vegetation forecasting skill in several areas of the world, particularly areas lacking adequate rain gauge coverage (e.g. southern Africa) required to characterize rainfall inputs into a soil water balance model. Since the move to operations in Spring of 2014, the USDA FAS has demonstrated improvements in their crop monitoring and forecasting ability after applying the new satellite-based product, particularly in sparsely-instrumented countries with moderate-to-severe food security issues. The system is now being adapted to integrate future observations from the NASA Soil Moisture Active Passive (SMAP) mission which is expected to launch in January, 2015 and provide global soil moisture observations at enhanced spatial resolutions and accuracy. Operational delivery of the SMOS-based soil moisture product will continue until the transition to SMAP data in mid-2015. As a SMAP ‘Early Adopter’, the project team has prepared a prototype system that is analogous to future SMAP data and have demonstrated the improved soil moisture monitoring potential that is expected from the SMAP-based soil moisture data assimilation system.

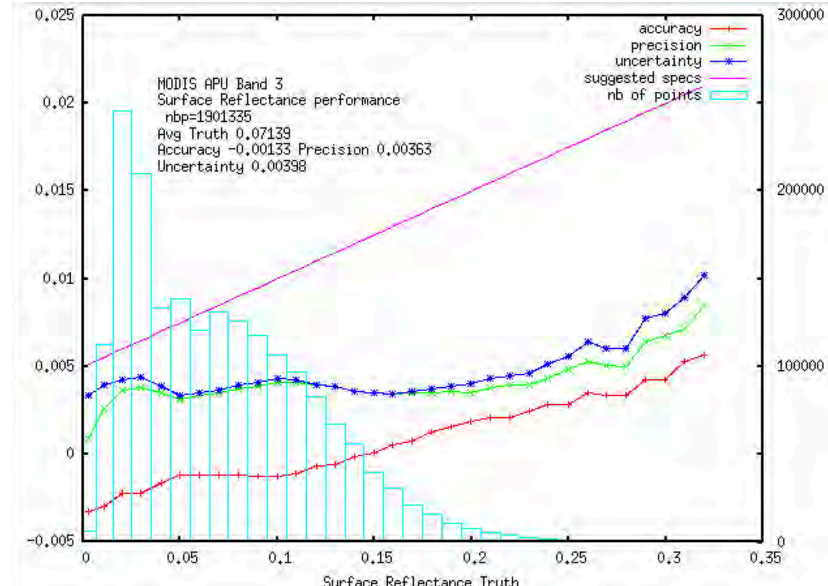
# Landsat 8 Surface reflectance performance evaluation

**Eric Vermote, Code 619, NASA GSFC**

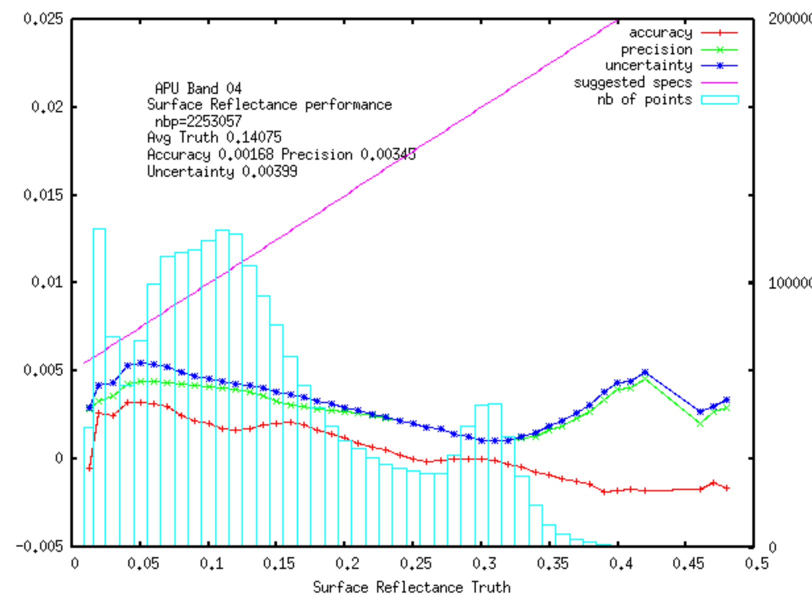
## LEDAPS




## WELD uses MODIS aerosol




## LANDSAT8 even better than WELD




Surface reflectance (SR) is a critical input to a variety of land surface variables (Vegetation index, BRDF etc..), the red band is used in a variety of these products and its performance is critical. The newly developed Landsat 8 (SR) shows enhanced performance compared to ETM+ (LEDAPS) and slightly better performance than a more constraining approach (WELD) in all spectral bands (here only the red band is shown). This improvement translates to ~0.01 in NDVI units which is of significance for long term trend studies and prediction of agricultural yields from remote sensing.

Name: Eric Vermote, NASA/GSFC, Code 619
E-mail: eric.f.vermote@nasa.gov
Phone: 301-614-5413

**Abstract:**
Using the atmospheric correction scheme developed for MODIS (Vermote and Kotchenova, 2008), Surface Reflectance has been generated from data from several others sensors such as VIIRS and Landsat TM/ETM+ (Masek et al., 2006) (LEDAPS). For ETM+ a variation that uses MODIS aerosol has also been implemented for the WELD project (Ju et al., 2012). Due to the difficulty of measuring accurately the reflectance on the ground at the needed scale, the approach for Surface Reflectance accuracy assessment (validation) relies primarily on the use of accurate radiative transfer code and accurate atmospheric and aerosol characterization such as provided by AERONET ground-based measurements. Using the top of the atmosphere reflectance measured by the sensor, the radiative code and AERONET measurements, a reference can be derived that can be compared to the surface reflectance product and accuracy metrics can be derived over a variety of conditions and locations. We present here the validation results obtained with the surface reflectance product from LDCM/Landsat 8 that was derived over 72 coincidences with AERONET, we also show the same performance metrics for Landsat ETM+ using LEDAPS and WELD .

**References:**

Ju, J., Roy, D.P., Vermote, E., Masek, J., Kovalskyy, V., 2012, Continental-scale validation of MODIS-based and LEDAPS Landsat ETM+ atmospheric correction methods, **Remote Sensing of Environment**, 122, 175–184. http://dx.doi.org/10.1016/j.rse.2011.12.025

Masek J.G., Vermote E.F., Saleous N.E., Wolfe R., Hall F.G., Huemmrich K.F., Gao F., Kutler J., Lim T.K., 2006. A Landsat surface reflectance dataset for North America 1990-2000, **IEEE Geoscience and Remote Sensing Letters**, 3, (1), 68-72.

Vermote, E. F., and S. Kotchenova, 2008. Atmospheric correction for the monitoring of land surfaces, **Journal of Geophysical Research**, 113, D23S90, doi:10.1029/2007JD009662.

**Data Sources:** the input data were produced by the USGS, the surface reflectance product is being tested and generated by Code 619.

**Technical Description of Figures:**

**Figure 1: (Top Left)** Performance of the LEDAPS ETM+ surface reflectance in the red band, the reference data are derived using AERONET, the metrics analyzed for each reflectance level are accuracy (the mean bias), precision (the standard deviation after removal of the bias) and uncertainty that is the quadratic mean of accuracy and precision, **(Top right)** same as top left but for the WELD/ETM+ surface reflectance, **(Bottom Right)** the performance of the Landsat 8 surface reflectance product in the red band.

**Scientific significance:**
The spectral bidirectional surface reflectance is a key input parameter to a potential suite a land products e.g. Vegetation Indices, Albedo, LAI/FPAR.

**Relevance for future science and relationship to Decadal Survey:**
This is extremely relevant to future science that necessitate the use of different data set in combination. The surface reflectance is the first step toward the fusion of data sets from different sensors.